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Plant Balance in Strawberry

Part of Optimal Soft Fruit Chain-project

Worldwide Expertise for Food & Flowers

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Onderstaande partijen zijn bij het project betrokken geweest als financier of uitvoerder:

Content

Summary

After several years of research on measuring and predicting strawberry quality, the development of a model to assist growers in planning distribution and harvest is getting closer. Vision technology can accurately predict parameters such as Brix, ripeness, and firmness of ripe strawberries. The goal is to create a cultivation plan based on weather forecasts and market conditions. This is challenging due to various factors like different cultivars, growing systems, and the concept of plant balance (the balance between the source and sink of assimilates). Plant balance is influenced by the source (light, CO_2) and sink (fruit development). Imbalance can lead to reduced production or quality.

The research aims to optimize the plant balance in everbearing cultivars, its effects on quantity, quality, development rate, and assimilate distribution, and the role of plant balance in harvest prediction.

In the greenhouse, the everbearing variety Favori is used with different plant densities and pruning strategies. Five strategies are tested, including conventional cultivation, reduced sink (fruit development), and varying plant densities. Measurements include plantload (fruits and flowers per plant), production, Brix, dry matter content, and shelf life. Climate conditions are recorded using a climate system.

In the trial was observed that plants grown at higher density were taller, while those at lower density remained more compact. Higher plant density resulted in the highest production, though reduced sink decreased yield. No significant differences in fruit size or shelf life were found between treatments. However, Brix levels were highest in the lower density plants, with no differences in dry matter content. Although the trial offered valuable insights into plant balance, a longer cultivation period is required for more definitive conclusions.

1. Introduction

After several years of measuring, quantifying, and predicting strawberry quality, the development of a model that will assist growers in planning distribution and harvest is getting closer. Vision technology has been developed to accurately predict key quality parameters (such as Brix, ripeness, and firmness) of ripe strawberries. Additionally, based on plant load and climate conditions, assumptions can be made regarding the quality and quantity of harvestable strawberries.

Ideally, growers could use these tools and historical data to create a cultivation plan based on weather forecasts and market conditions (primarily strawberry prices). This would allow them to accurately inform the distribution chain about strawberries' expected quality and quantity at a specific time, even before cultivation begins. These tools are already being developed and used for some crops like chrysanthemums and tomatoes, but creating a planning tool for strawberries is much more challenging due to the different cultivars, planting types, cultivation systems, growing methods, and plant varieties, as well as the concept of 'plant balance'—a term used to describe the balance between the source and sink of assimilates.

1.1. Goals

The goal of the trial is to increase knowledge in understanding plant balance of everbearing cultivars by applying different plant handling strategies, as well as validating the quality measurement system in case of different plant balances. The research questions are:

- How does the plant balance affect fruit quantity?
- How does the plant balance affect fruit quality?
- How does the plant balance affect the development rate?
- How does the plant balance affect assimilate distribution?
- How important is plant balance for the prediction of the harvest window and fruit quality?

2. Approach and greenhouse design

2.1. Greenhouse design

For this trial, the everbearing variety Favori has been chosen. Fresh tray plants have been used for planting.

- Plantdate: 18th of January 2024
- First harvest: 25th of March 2024
- Last harvest: 27th of June 2024
- Amount of plant per m^2: 7, 5 or 10 plants/m^2

The greenhouse equipment was as follows:

Compartment:	Greenhouse 3.4, Delphy Improvement Centre, Bleiswijk
Area:	gross area: 168 m^2, net area: 144 m^2
Bar width:	9.60 meter
Foot height:	6.86 meter
Greenhouse cover:	“Venlo” roof
Glasstype:	Saint Gobain Ultra Low Haze 2xAR
Heating:	heating pipe and growing pipe
CO_2 dosing:	OCAP pure CO_2
Climate computer:	Priva
Substrate:	Coco mix
Screen installation:	Obscura 9950 FR W Luxous 1147 FR
Irrigation:	1 valve group, by drippers

2.2. Treatments and Hypothesis

Five strategies were tested:

1) Conventional (no extra crop handling, 7 plants per running meter)
2) Decreased sink (max. 4 trusses per plant)
3) Extreme decreased sink (max. 2 trusses per plant)
4) Decreased plant density (4 plants per running meter)
5) Higher plant density (10 plants per running meter)

The hypotheses were as follows:

- Removing the young trusses will decrease the sink strength of the crop. The hypothesis is that these plants will show more vegetative growth and develop more crowns. As long as new trusses are removed, the plants should be able to maintain fruit size.
- The plant density will influence the amount of crowns the plants can make. A lower plant density will result in more crowns per plant, which can result in peak plantload if all crowns are developed at around the same time. A higher plant density will result in fewer crowns per plant and may lead to a more stable production pattern and fruit quality.

The greenhouse set-up is shown in Figure 2-1.

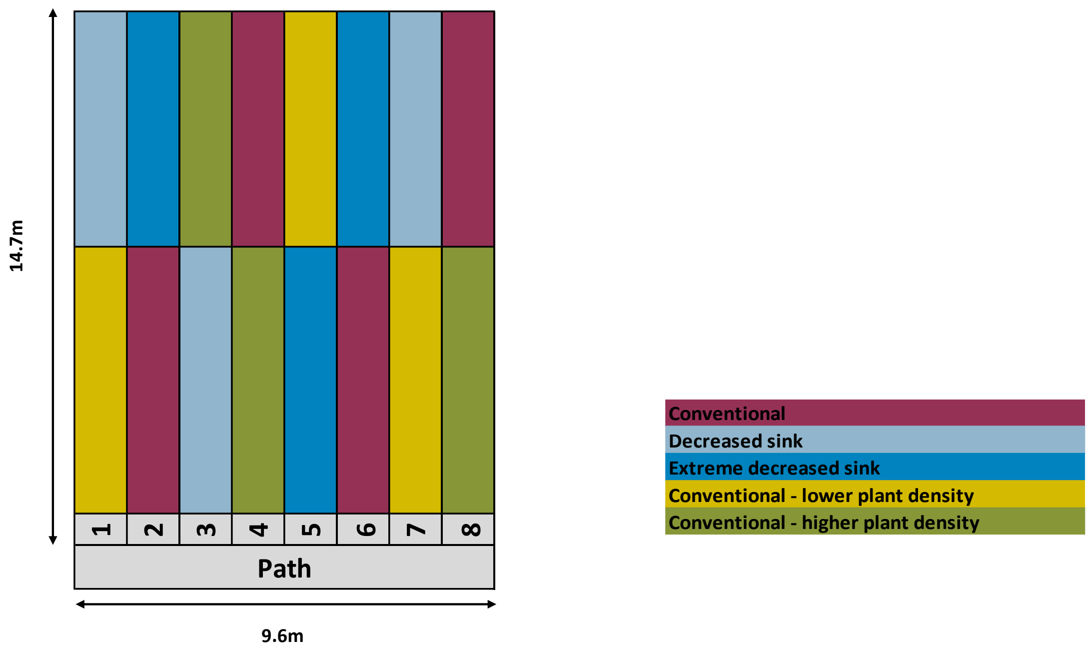

Figure 2-1. Greenhouse set-up.

2.3. Measurements

The following measurements were carried out:

- Plantload (fruits and flowers per plant, 5 plants per plot)
- Flower abortion (5 plants per plot)
- Plant height (5 containers per plot)
- Plant width (5 containers per plot)
- Production (in sortings (mm) of 35+, 30+, 27+, 25+ and Class II and waste)
- Brix (10 fruits per plot for each harvest)
- Dry matter content (10 fruits per plot for each harvest week)
- Shelf life (loss of fresh weight after picking 10 strawberries/plot)
- LAI (Leaf area index based on 5 measured plants)
- With the vision system, daily measurements:
    - Number of fruits + height, width and color (index) of each fruit

The climate will be recorded using a measuring box (Priva).

3. Plant Balance

The source of assimilates is determined by photosynthesis and depends on factors like light, CO_2 concentration, temperature, and light interception (determined by the Leaf Area Index and the stretching of petioles). The sink, or consumption of assimilates, is mainly influenced by plant and fruit growth. In everbearing crops, if the demand (sink) for assimilates is too high, production and quality will decrease. If the demand is too low, quality will be good, but production could have been higher and thus more efficient. The key factors affecting both the source and sink are shown in Table 3-1. Currently, plant balance remains a subjective parameter. To use plant balance in predicting yield and fruit quality, data is needed to make the concept of plant balance more objective.

Table 3-1. Factors influencing plant balance.

Factors influencing source	Factors influencing sink
Leaf Area: - Number of leaves - Leaf age - Size of leaves - Stretching of petioles (length of leaf and potential of light interception)	Plantload: - Number of fruits and flowers per plant - Fruit weight
Light level: - Light intensity - Daylength/Photoperiod - Light interception	Plant development: - New crowns - New leaves - New roots - Stolons (runners)
Microclimate: - Temperature around the plant (higher temperature also results in higher photosynthesis if CO_2 is sufficient) - Air movement around plants - Humidity around plants - CO_2 concentration	Temperature: - Direct effect: higher temperature increases assimilate consumption of all plant parts - Indirect effect: higher temperatures cause quicker development leading to 'peak' plant loads

3.1. Brix prediction model validation

The cameras for the Brix prediction model were placed on the 6th of February 2024 at the treatment 'Conventional'. On the 17th of May, the cameras were moved to the treatment 'Higher plant density'. The strawberries in the camera sight were labelled and measured. The label was a sticker on the fruit stem with the camera number and fruit number. After picking the fruits were measured (Brix) by hand and later with the model to see how precise the model is.

The treatments had different plant densities and pruning strategies. In Table 3-2 are the treatments explained.

Table 3-2. Treatments with plant density and pruning strategy

Treatment	Plant density	Pruning strategy
Conventional	7 plants/meter	None
Decreased sink	7 plants/meter	Maximum 4 trusses; Every 2 weeks all new trusses were removed except for 2 trusses.
Extreme decreased sink	7 plants/meter	Maximum 2 trusses; Every 2 weeks all new trusses were removed except for 1 truss.
Lower plant density	5 plants/meter	None
Higher plant density	10 plants/meter	None

4. Results

4.1. Realised climate

During the trial, the climate was measured using a climate box of Priva. The light was measured in PAR. The average PAR is shown in Figure 4-2. The average peak at day was around 500 µmol/m^2/s and the average daylength was 13.5 hours.

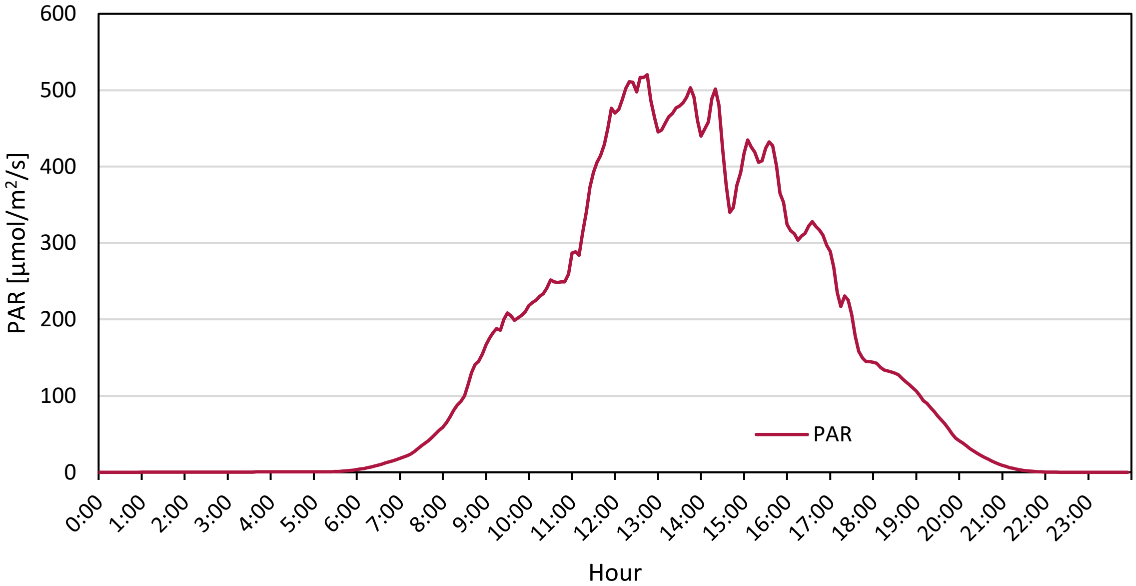

Figure 4-2. Average measured PAR per hour during the trial in µmol/m²/s.

The 24h, maximum and minimum temperature in the greenhouse during the trial is shown in Figure 4-3. The overall average 24h temperature was 17.4°C. The average temperature per hour during the day is shown in Figure 4-4. The average day temperature was 19.3°C and the average night temperature was 14.2°C

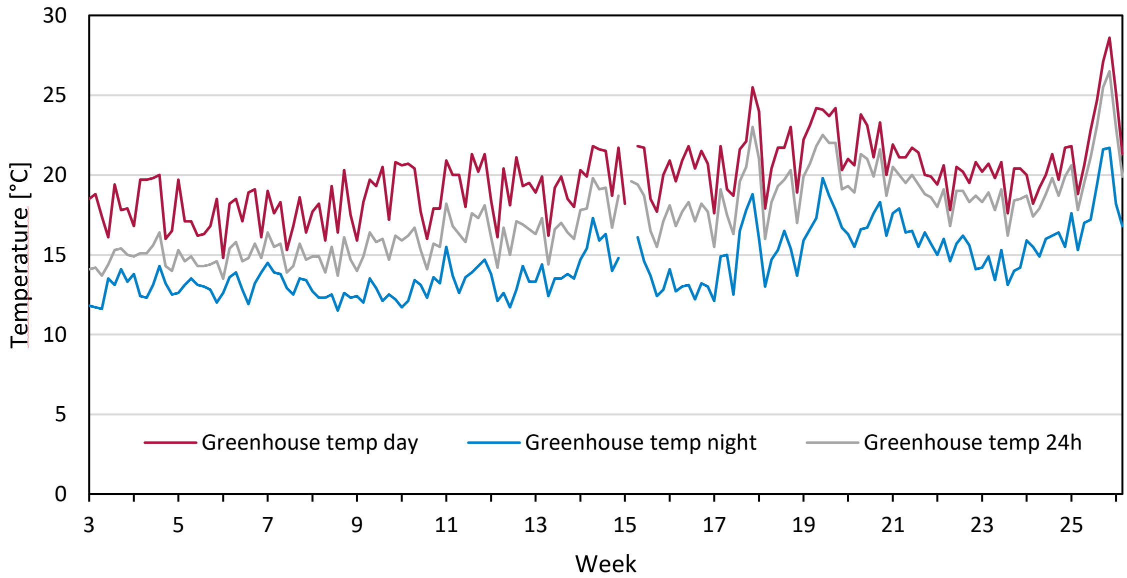

Figure 4-3. Measured 24h temperature, maximum temperature and minimum temperature per day in °C during the trial.

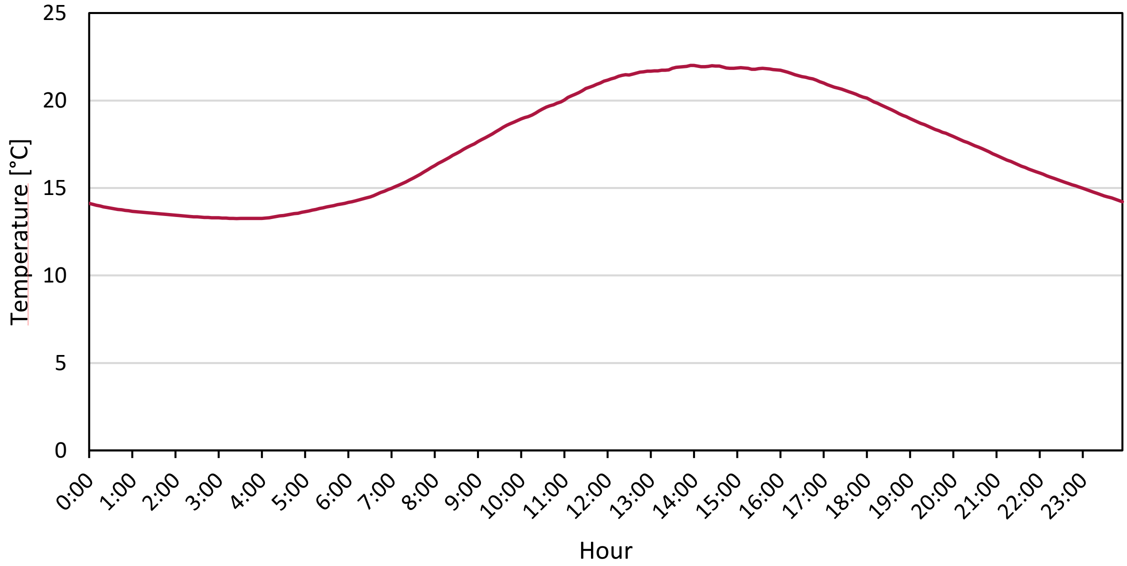

Figure 4-4. Average temperature per hour in °C. The average 24h temperature was 17.4°C.

The humidity in the greenhouse can be expressed in different ways. In Figure 4-5 is the average of relative humidity, absolute humidity and humidity deficit shown per hour. The average day relative humidity was 72% and the average night relative humidity was 82%.

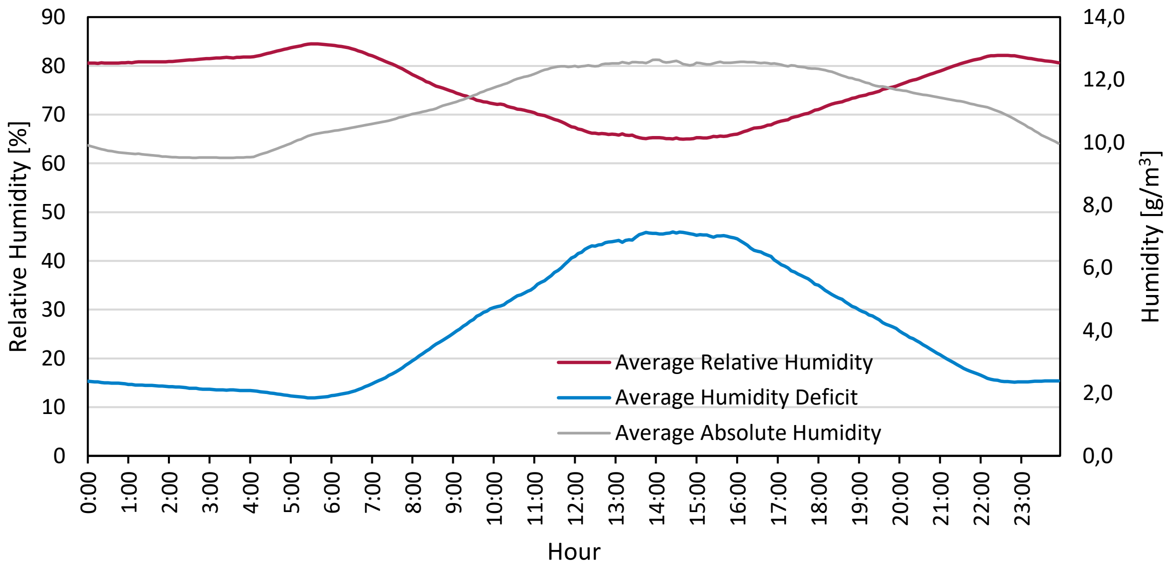

Figure 4-5. Average relative humidity, absolute humidity and humidity deficit per hour. The average 24h relative humidity was 75.5%, the absolute humidity was 11.2 g/m³ and the humidity deficit was 4 g/m³.

4.2. Plant development and production

Several parameters were measured throughout the trial, as explained in paragraph 2.3. The height and width of the plants are shown in Figures 4-6 and 4-7, respectively. These figures show that the plants in 'Higher plant density' stretched the most. In 'Lower plant density', they stayed the most compact.

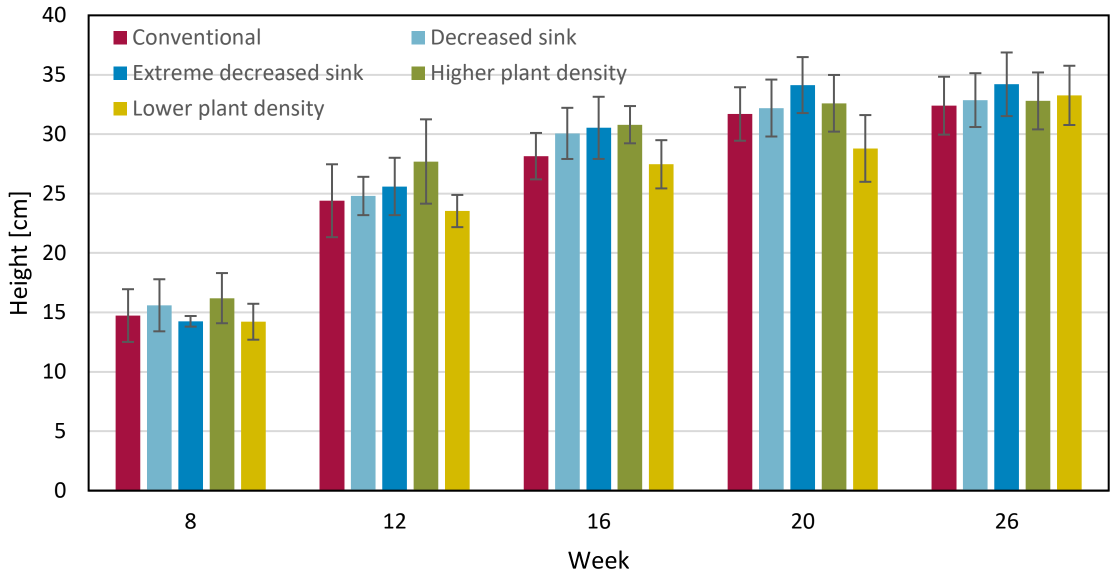

Figure 4-6. Average height per treatment per week. The overall averages are conventional 26.9 cm, decreased sink 27.5 cm, extreme decreased sink 29.8 cm, higher plant density 31.1 cm and lower plant density 25.6 cm.

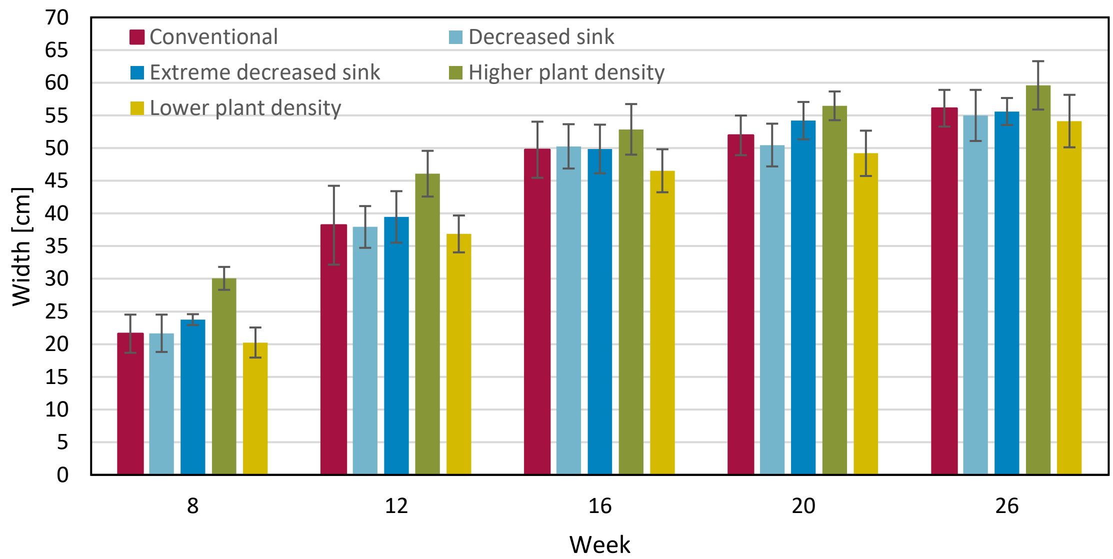

Figure 4-7. Average width per treatment per week. The overall averages are conventional 44.7 cm, decreased sink 44.1 cm, extreme decreased sink 47.8 cm, higher plant density 53.9 cm and lower plant density 41.7 cm.

The Leaf Area Index is shown in Figure 4-8. There is no difference between the treatments.

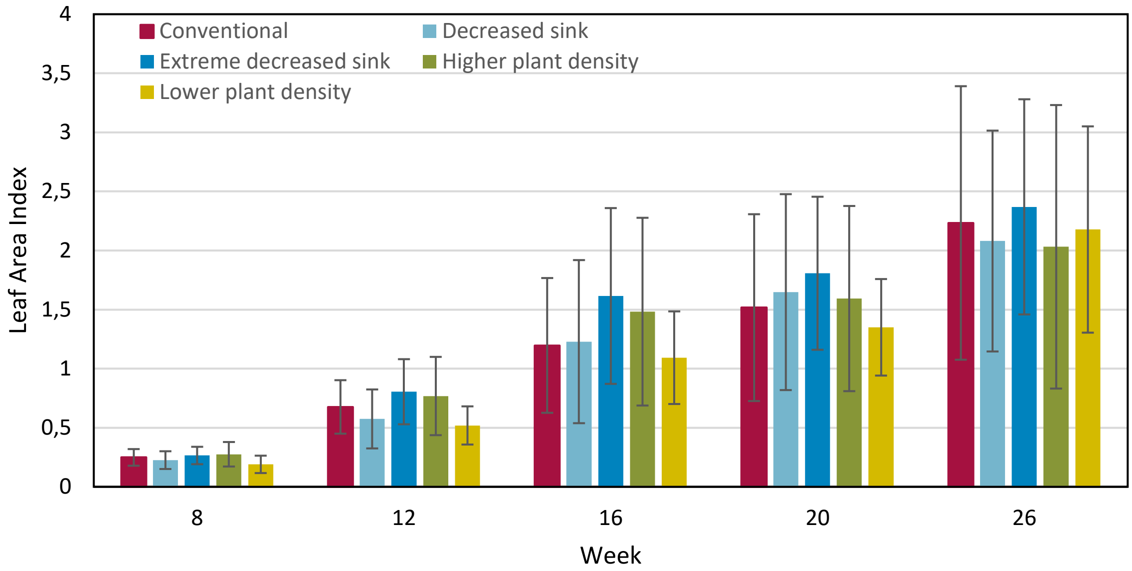

Figure 4-8. Average Leaf Area Index per treatment per week. The overall averages are conventional 1.1 m²/m², decreased sink 1.2 m²/m², extreme decreased sink 1.4 m²/m², higher plant density 1.4 m²/m² lower plant density 1.1 m²/m².

The plantload is an important factor of sink. Figure 4-9 shows the average plantload per meter per treatment. The plantload was slightly higher in 'Higher plant density'. In the last couple of weeks 'decreased sink' has the lowest plantload. It was expected that 'Extreme decreased sink' would have the lowest plantload. However, that is not the case. It is not clear what made the difference. It could be that the amount of fruits per truss was different or that the pruning strategy was not effective.

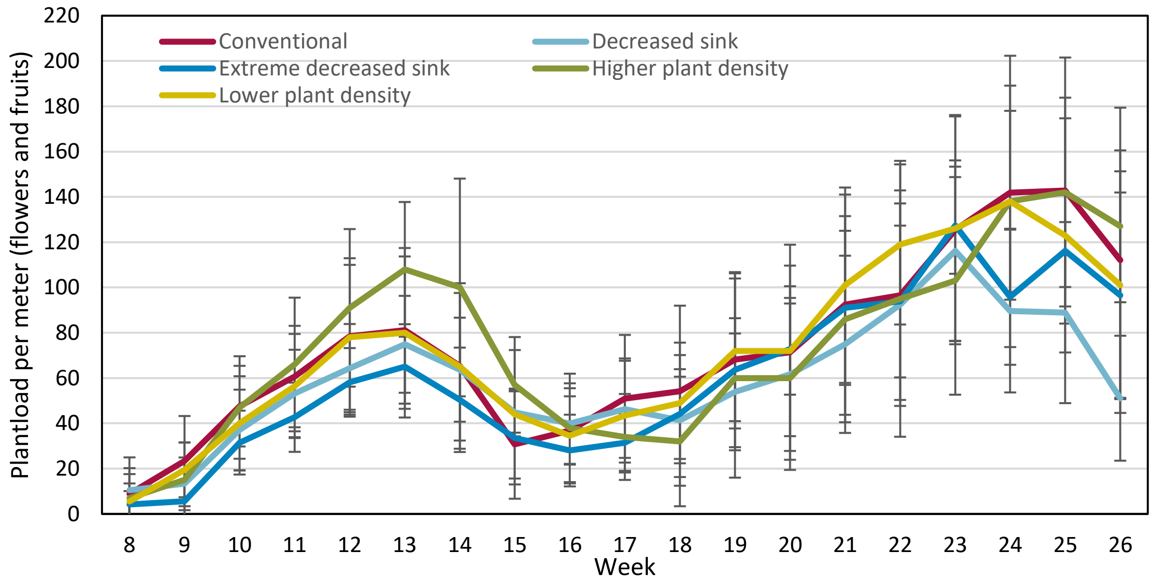

Figure 4-9. Average plantload per meter per treatment per week. The overall averages are conventional 60.1, decreased sink 52.4, extreme decreased sink 48.7, higher plant density 63.5 and lower plant density 61.3.

The average production of class I per week per treatment is shown in Figure 4-10. The cumulative of this weekly production as well as the cumulative production of the total harvest is shown in Figure 4-11. On average there is no difference between the productions, but 'Higher plant density' had the highest end production. In the last few weeks, there have been differences visible between the weekly productions. It is clear that the truss pruning caused a lower production.

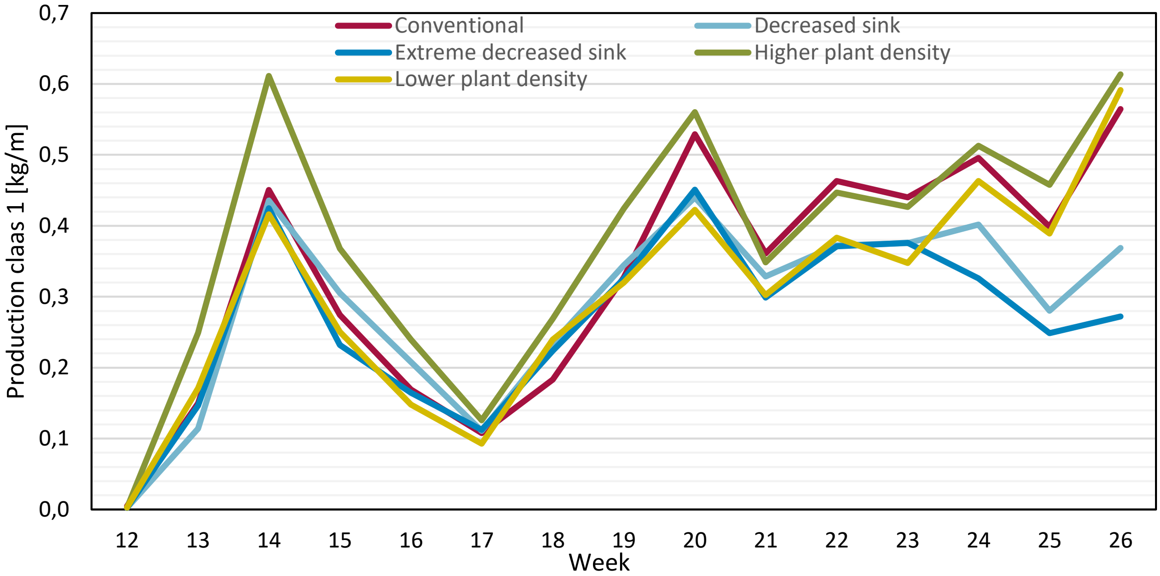

Figure 4-10. Average production of class 1 fruits per meter per week. The overall averages are conventional 0.33 kg/m, decreased sink 0.29 kg/m, extreme decreased sink 0.26 kg/m, higher plant density 0.38 kg/m lower plant density 0.30 kg/m.

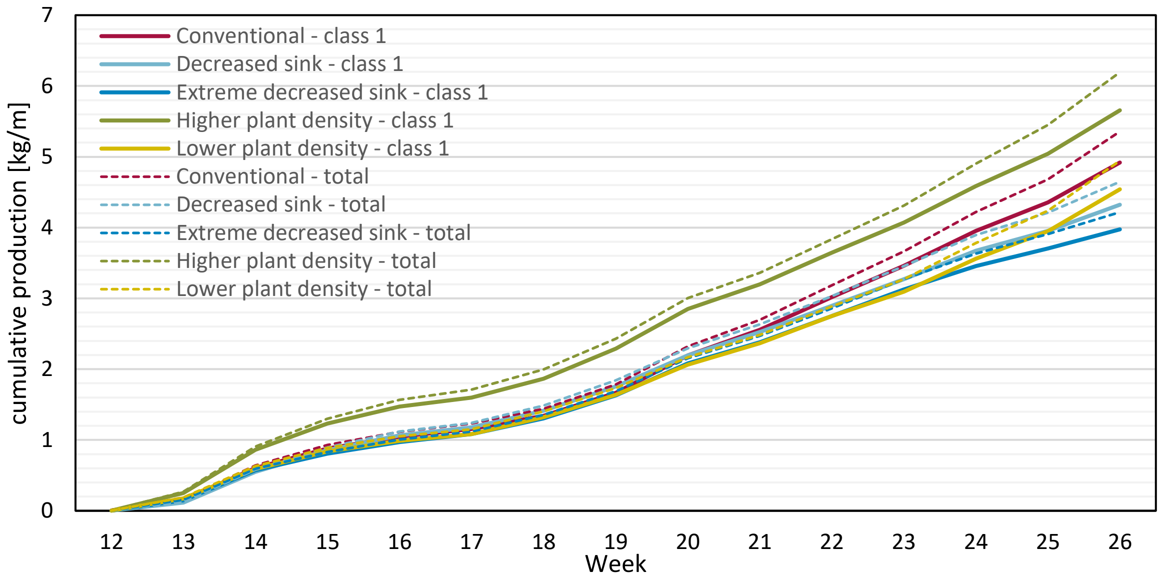

Figure 4-11. Cumulative production of class 1 and total fruits. The total amounts of production of class 1 are conventional 4.92 kg/m, decreased sink 4.32 kg/m, extreme decreased sink 3.97 kg/m, higher plant density 5.66 kg/m and lower plant density 4.54 kg/m.

The proportion of the different classes per harvest is shown in Figure 4-12. The fruitsize is not different between the treatments.

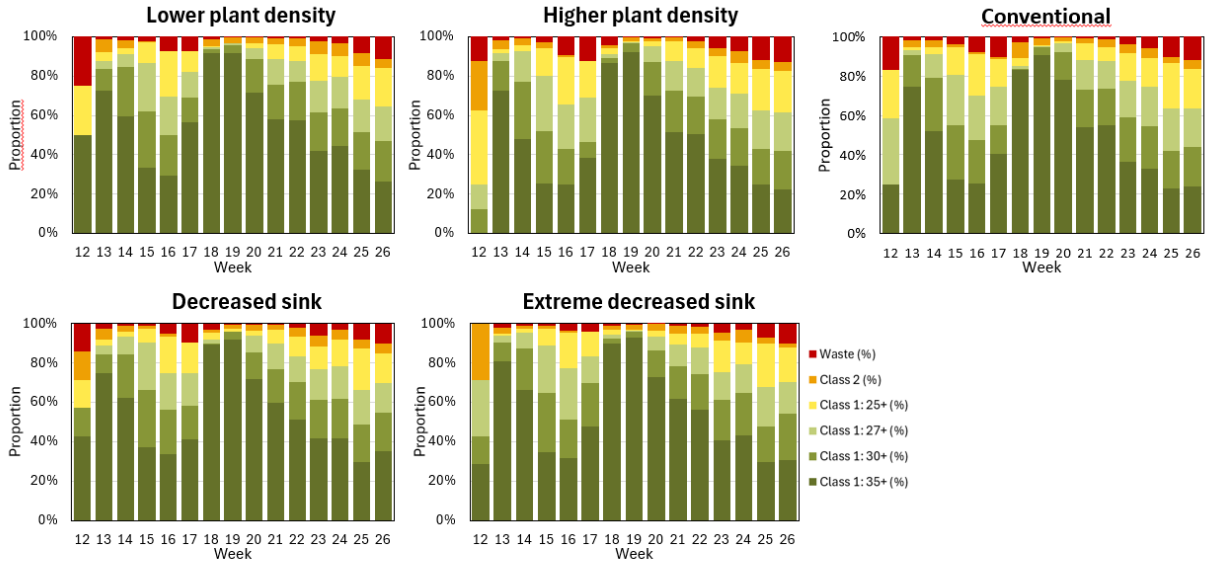

Figure 4-12. The proportion of fruit sortings per treatment per week.

The shelf life results are shown in Figure 4-13. There is no difference between the treatments. However, the shelf life of the harvest in week 16 was better (less weight loss) than the other weeks. It could be that the fruits, which were harvested in week 16, were less ripe than the others, but that is not clear.

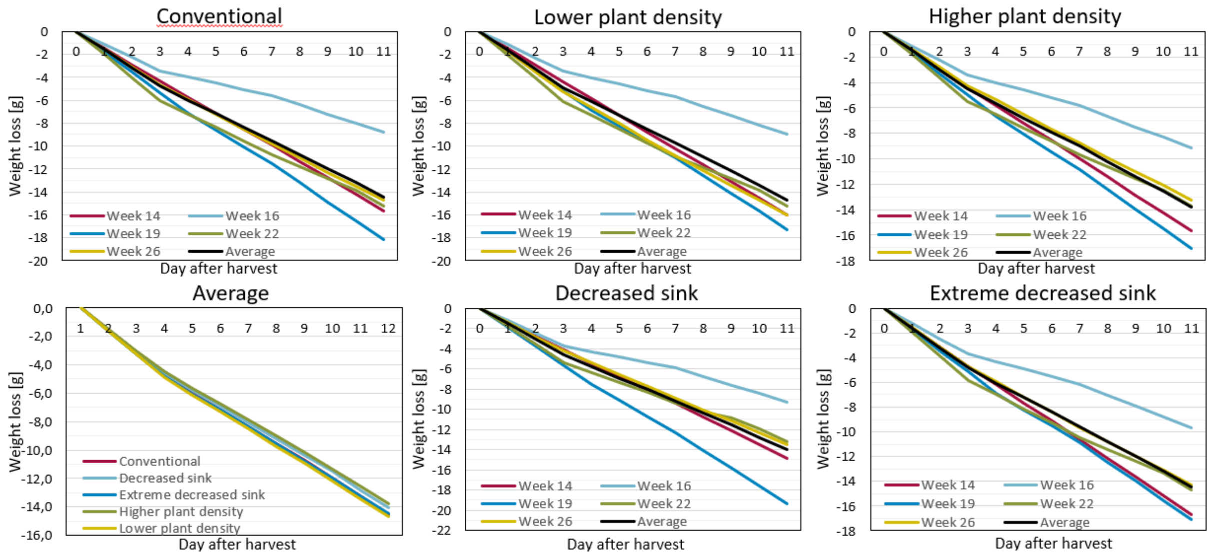

Figure 4-13. Shelf life in weight loss per day after harvest per week per treatment and average per treatment.

The average Brix per week per treatment is shown in Figure 4-14. 'Lower plant density' had the highest average Brix.

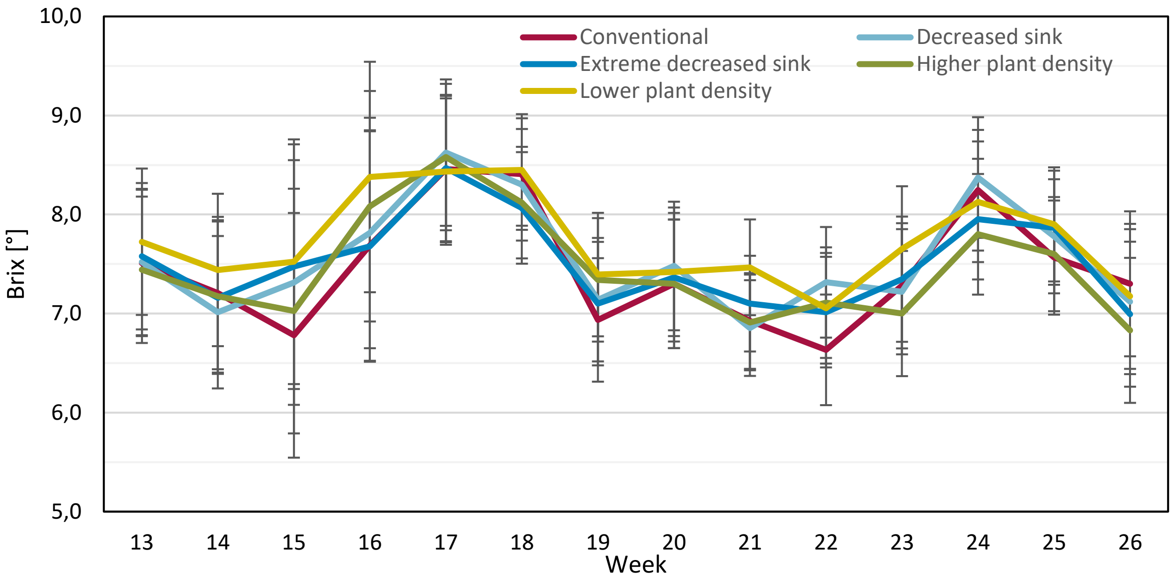

Figure 4-14. Average Brix per treatment per week. The overall averages are conventional 7.4°, decreased sink 7.6°, extreme decreased sink 7.5°, higher plant density 7.5° and lower plant density 7.7°.

The dry matter content of the fruits per treatment per week is shown in Figure 4-15. There are no differences between the treatments.

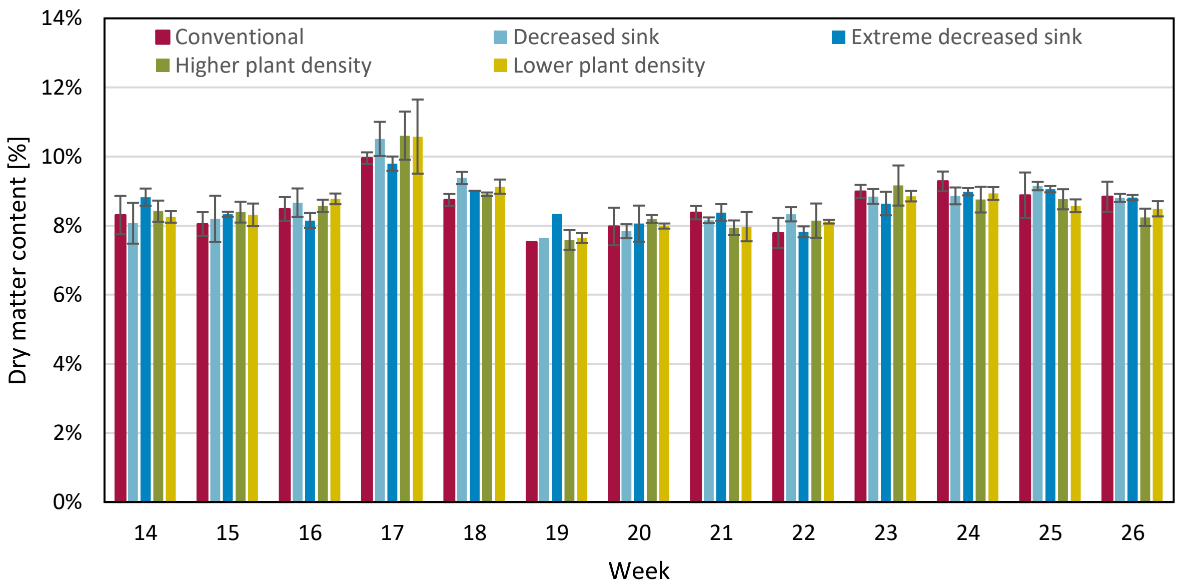

Figure 4-15. Average dry matter content per treatment per week. The overall averages are conventional 8.6%, decreased sink 8.7%, extreme decreased sink 8.6%, higher plant density 8.6% and lower plant density 8.6%.

5. Conclusions

Development rate

- With a higher plant density, the plants stretch more to catch the light.
- There was no difference in leaf area index.
- The plantload was lowest in ‘Decreased sink’.

Quantity

- The highest production was achieved with ‘Higher plant density’.
- Only in the last few weeks the truss pruning resulted in less production.

Quality

- There were no differences in fruit size between the treatments.
- All the fruits had the same shelf life, only production week made a difference.

Assimilate distribution

- The Brix was highest in ‘lower plant density’.
- The dry matter was not different between the treatments.

The trial had learnings about plant balance, but the cultivation needs to be longer for clearer conclusions.